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(71) Applicant (for all designated States except US): SPECTRUM SCIENCES B.V. [NL/NL]; Lange Vijverberg 9, NL-2513 AC The Hague (NL).

(72) Inventors; and

(75) Inventors/Applicants (for US only): SAGIV, Oded [IL/IL]; P.O. Box 930, 44 864 Cochav Yair (IL). LANDA, Benzion [CA/CA]; 10010-119 Street, Edmonton, Alberta T5K 1Y8 (CA). BLUM, Yoram [IL/IL]; Bialik 6, 51 905 Givat Shmuel (IL).

(74) Agent: DE BRUIJN, Leendert, C.; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL).

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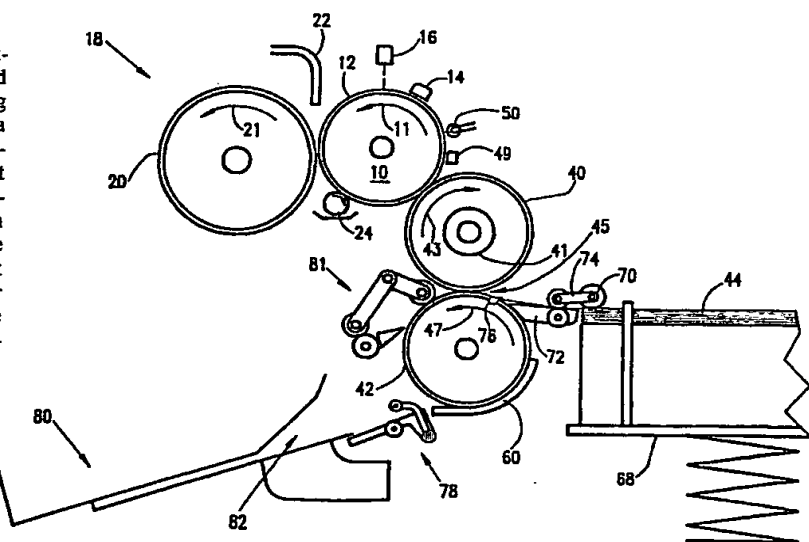
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(54) Title: DUPLEX PRINTER

(57) Abstract

Imaging apparatus for duplex printing on a substrate having first and second sides and a leading edge and a trailing edge, the imaging apparatus including a first member having an image support surface adapted to sequentially support first and second images thereon, a second member adapted to support the substrate such that one side of the substrate engages the image support surface, leading edge first, at a transfer region and transfer apparatus for transferring the first image from the image support surface to the first side of the substrate at the transfer region while at least partially fixing the image thereto. The imaging apparatus also includes a waiting station adjacent the second member for receiving the substrate after transfer of the first image thereto and prior to the transfer of the second image thereto and an output station for receiving the substrate after completion of image transfer thereto. The imaging apparatus includes deflector apparatus adjacent the second member operative to receive the substrate directly from the second member and selectably deflect the substrate towards the waiting station or the output station for delivery thereto and roller apparatus associated with the waiting station for selectably engaging the trailing edge of the substrate after the substrate has been delivered to the waiting station for delivering the substrate back to the second member. The second member is operative to deliver the substrate to the transfer region, whereat the second image is transferred to the second side of the substrate.



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DUPLEX PRINTER**FIELD OF THE INVENTION**

The present invention relates generally to liquid toner electrographic imaging systems and more particularly to duplex printing apparatus for liquid toner electrographic imaging systems.

BACKGROUND OF THE INVENTION

Apparatus for duplex copying of documents and for duplex printing by means of laser printers are known in the art. United States Patent 4,949,949 to Holmes et al. describes a "Hybrid Sequencing Duplex Automatic Document Handling System" which includes apparatus for handling document sheets both sides of which are to be copied and for making duplex (i.e. double-sided) copies of such document sheets. The apparatus involve the use of one or more pairs of reversible rollers, lengthy inversion paths, and buffer trays for the handling of the documents and the copy paper prior to and in the course of making duplex copies. United States Patent 4,884,794 to Dinatale et al. describes a document handler for duplex photocopying having first and second inverting path segments, which are utilized to re-orient the copy paper prior to duplex copying. United States Patent 5,003,355 to Tanzawa describes a sheet transport control apparatus for use in a duplex unit of a laser printer, the apparatus including a transport system and a switchback system, and a series of driving motors and sensors. All the systems described in the prior art share the common feature of being mechanically complex, and they all involve transporting the paper through relatively lengthy and convoluted paths after printing on the first side so as to be able to print on the second side.

SUMMARY OF THE INVENTION

The present invention provides apparatus and a method for duplex printing that is significantly simpler than those described in the prior art. More specifically, the present invention provides apparatus and a method for duplex printing involving a short and straight transport path, without need for inverting segments and/or complex control mechanisms. As a consequence, the present invention affords duplex printing

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1 that is remarkably fast and efficient, and enables printing
2 on both sides of a sheet of paper without any significant
3 waiting time. There is therefore provided in accordance with
4 the invention imaging apparatus for duplex printing on a
5 substrate having first and second sides and a leading edge
6 and a trailing edge, the apparatus including:

7 a first member having an image support surface adapted to
8 sequentially support first and second images thereon;

9 a second member adapted to support the substrate such
10 that one side of the substrate engages the image support
11 surface, leading edge first, at a transfer region;

12 means for transferring the first image from the image
13 support surface to the first side of the substrate at the
14 transfer region while at least partially fusing and fixing
15 the image thereon;

16 a waiting station adjacent the second member for
17 receiving the substrate after transfer of the first image
18 thereto and prior to the transfer of the second image
19 thereto;

20 an output station for receiving the substrate after
21 completion of image transfer thereto;

22 deflector means adjacent the second member operative to
23 receive the substrate directly from the second member and
24 selectably deflect the substrate towards the waiting station
25 or the output station for delivery thereto; and

26 roller means associated with the waiting station for
27 selectably engaging the trailing edge of the substrate after
28 the substrate has been delivered to the waiting station and
29 for delivering the substrate back to the second member, the
30 second member being operative to deliver the substrate to the
31 transfer region, whereat the second image is transferred to
32 the second side of the substrate.

33 In accordance with a preferred embodiment of the
34 invention, the second member includes gripping means for
35 gripping the edge of the substrate which enters the transfer
36 region first and is adapted for repeatedly engaging the same
37 side of the substrate with the image support surface, such
38 that at each engagement a different color image is

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1 transferred thereto.

2 In accordance with another preferred embodiment of the
3 invention, the deflector means includes a roller and a set of
4 wheels engaging the roller and forming a nip through which
5 the substrate is transported, the set of wheels being
6 adapted to engage the roller at first and second positions,
7 at the first position the angle of release of the substrate
8 from the nip is such that it is deflected to the waiting
9 station, and at the second position the angle of release of
10 the substrate from the nip is such that it is deflected
11 to the output tray.

12 In accordance with yet another preferred embodiment of
13 the invention, the deflector means includes:

14 a shaft;

15 a motorized roller;

16 pairs of arms joined to each other at a pivot and spring-
17 loaded with respect to each other at the pivot, one of the
18 arms fixedly attached to the shaft and the other arm having a
19 wheel rotatably attached thereto and forming a nip with
20 respect to the roller; and

21 means for rotating the shaft to first and second
22 positions, whereby at the first position the deflector means
23 is operative to deflect the substrate to the waiting station
24 and at the second position the deflector means is operative
25 to deflect the substrate to the output station.

26 In accordance with another preferred embodiment of the
27 invention, the pairs of arms which are part of the deflector
28 means are axially distanced from each other along the shaft
29 and are axially slideable along the shaft. The shaft also
30 includes stiffener members axially slideable thereon.

31 In accordance with another preferred embodiment of the
32 invention, the deflector means is operative to deflect a
33 substrate to the waiting station while the roller means is
34 operative to deliver a different substrate from the waiting
35 station back to the second member.

36 In accordance with yet another preferred embodiment of
37 the invention, the roller means includes a motorized set of
38 wheels and a roller selectably adapted to engage the trailing

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1 edge of the substrate at a nip formed with the wheels. In
2 this embodiment, the roller is in an open, disengaged
3 position with respect to the wheels prior to the deflection
4 of a substrate to the waiting station, such that the trailing
5 edge of the substrate contacts the wheels when it is
6 deflected to the waiting station, and the roller is in a
7 closed, engaged position with respect to the wheels when the
8 substrate is delivered back to the second member.

9 In accordance with another preferred embodiment of the
10 invention, the roller means includes:

11 a base plate having at least one aperture therethrough;
12 a motorized rotatable shaft having at least one
13 rubberized wheel mounted thereon and extending through the
14 aperture; and

15 at least one roller pivotally mounted with respect to the
16 plate, and selectably operative to form a nip with respect to
17 the at least one wheel for delivery of a substrate
18 therethrough, whereby the at least one roller is in a first
19 disengaged position with respect to the at least one wheel
20 prior to the deflection of a substrate to the waiting station
21 and in a closed, engaged position with respect to the at
22 least one wheel when the substrate is delivered back to the
23 second member.

24 In accordance with another preferred embodiment of the
25 invention, the imaging apparatus includes means for causing
26 the engagement of the first sides of sequential substrates
27 with the image bearing surface for image transfer thereto
28 prior to causing the engagement of the second sides of
29 sequential substrates for image transfer thereto.

30 In accordance with yet another preferred embodiment of
31 the invention, there is provided apparatus for printing toner
32 images on both sides of a plurality of sequential substrates,
33 the apparatus including:

34 printing means for printing toner images on one side of a
35 substrate;

36 a waiting station spaced closely to the printing means
37 and adapted for holding only one substrate at any one time
38 after printing of images on the first side thereof; and

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1 delivery means associated with the waiting station for
2 delivering a substrate from the waiting station back to the
3 printing means for printing on the second side thereof, a
4 first substrate being removed from the waiting station while
5 another substrate is being delivered to the waiting station
6 after printing on the first side thereof.

7 In accordance with another preferred embodiment of the
8 invention, there is provided a method for printing images on
9 first and second sides of sequential substrates, the method
10 comprising the steps of:

11 (a) printing an image on the first side of a first
12 substrate;

13 (b) delivering the first substrate to a waiting station;

14 (c) printing an image on the first side of a subsequent
15 substrate;

16 (d) delivering the subsequent substrate to the waiting
17 station while removing the first substrate therefrom;

18 (e) printing an image on the second side of the first
19 substrate;

20 (f) delivering the first substrate to an output station
21 while removing the second substrate from the waiting station;

22 (g) printing an image on the second side of the
23 subsequent substrate.

24 (g) repeating steps (a) - (f) above for a plurality of
25 sequential substrates.

26 In accordance with yet another preferred embodiment of
27 the invention, there is provided a method for printing images
28 on first and second sides of sequential substrates, the
29 method comprising the steps of:

30 (a) printing an image on the first side of a first
31 substrate;

32 (b) delivering the first substrate to a waiting station;

33 (c) printing an image on the first side of a subsequent
34 substrate;

35 (d) delivering the subsequent substrate to the waiting
36 station while removing the first substrate therefrom;

37 (e) printing an image on the second side of the first
38 substrate;

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1 (f) delivering the first substrate to an output station;
2 (g) printing an image on the first side of a third
3 substrate;
4 (h) delivering the third substrate to the waiting station
5 while removing the second substrate from the waiting station;
6 (i) printing an image on the second side of the second
7 substrate.
8 (j) repeating steps (g) - (i) a plurality of times.
9 There is further provided, in accordance with a preferred
10 embodiment of the invention, a method for printing images on
11 first and second sides of sequential substrates utilizing
12 apparatus having an image bearing roller and an impression
13 roller forming a nip therebetween, including the steps of:
14 (a) passing a first substrate through the nip during a
15 first revolution of the image bearing roller to print an
16 image on the first side of a first substrate;
17 (b) delivering the first substrate to a waiting station;
18 (c) passing a second substrate through the nip during a
19 subsequent revolution of the image bearing roller to print an
20 image on the first side of the second substrate; and
21 (e) passing the first substrate through the nip during
22 the next revolution of the image bearing roller after the
23 subsequent revolution to print an image on the second side
24 of the first substrate.
25 In a further preferred embodiment of the invention there
26 is provided a method for printing images on first and second
27 sides of sequential substrates utilizing apparatus having an
28 image bearing roller and an impression roller forming a nip
29 therebetween, including the steps of:
30 (a) passing a first substrate through the nip during a
31 first series of revolutions of the image bearing roller to
32 print a plurality of color separation images on the first
33 side of a first substrate;
34 (b) delivering the first substrate to a waiting station;
35 (c) passing a second substrate through the nip during a
36 subsequent revolution of the image bearing roller thereby
37 printing an image on the first side of the second substrate;
38 and

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1 (e) passing the first substrate through the nip during
2 the next revolution of the image bearing roller after the
3 subsequent revolution to print an image on the second side
4 of the first substrate.

5 In a preferred embodiment of the invention the method and
6 includes the step of passing the second substrate through the
7 nip at least one time between step (a) and step (c) thereby
8 to print at least one additional image on the first side of
9 the second substrate.

10 Preferably, the first and second images are toner images,
11 more preferably liquid toner images.

12 In a preferred embodiment of the invention different
13 images are printed on the first and second substrates.

14 **BRIEF DESCRIPTION OF THE DRAWINGS**

15 The present invention will be understood and appreciated
16 from the following detailed description, taken in conjunction
17 with the drawings in which:

18 Fig. 1 is a schematic diagram illustrating multi-color
19 imaging apparatus in accordance with a preferred embodiment
20 of the invention.

21 Fig. 2 is a perspective view of substrate deflection
22 apparatus for duplex printing in accordance with a preferred
23 embodiment of the invention.

24 Fig. 3 is a partial side view of the apparatus of Fig. 1
25 showing operation of the apparatus of Fig. 2 in deflecting a
26 substrate to a waiting station.

27 Fig. 4 is another partial side view of the apparatus of
28 Fig. 1 showing operation of the apparatus of Fig. 2 in
29 deflecting a substrate to an output station.

30 Fig. 5 is a perspective view of substrate transport
31 apparatus for duplex printing in accordance with a preferred
32 embodiment of the invention.

33 Fig. 6 is a partial side view of the apparatus of Fig. 1
34 showing operation of the apparatus of Figs. 2 and 5 with one
35 sheet entering the waiting station while the previous sheet
36 is removed therefrom.

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1 **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

2 Reference is now made to Fig. 1 which illustrates a
3 liquid toner multi-color electrographic imaging system in
4 accordance with a preferred embodiment of the present
5 invention.

6 The apparatus of Fig. 1 includes a drum 10 which rotates
7 in a direction indicated by arrow 11 and which has a
8 photoconductive surface 12 made of selenium or any other
9 photoconductor known in the art. As drum 10 rotates,
10 photoconductive surface 12 passes a charging apparatus 14,
11 such as a corona, which is operative to charge
12 photoconductive surface 12 to a generally uniform pre-
13 determined voltage. Further rotation of drum 10 brings
14 charged photoconductive surface 12 past an imager 16,
15 preferably a laser scanner, which is operative to selectively
16 discharge a portion of the charged photoconductive surface
17 by the action of incident light so as to form thereon an
18 electrostatic latent image, the image portions being at a
19 first voltage and the background portions at a second
20 voltage.

21 Continued rotation of drum 10 brings photoconductive
22 surface 12 bearing the electrostatic latent image into a
23 development region where the latent image is developed by
24 means of a liquid toner developer assembly, referenced
25 generally by numeral 18. Developer assembly 18 includes a
26 developer roller 20, closely spaced from drum 10, and a
27 liquid toner spray apparatus 22. Developer roller 20 typical-
28 ly rotates in the same sense as drum 10, as indicated by
29 arrow 21, such that the surfaces of drum 10 and developer
30 roller 20 have opposite velocities at their region of propin-
31 quity. Developer roller 20 is electrified to a voltage that
32 is intermediate the voltages on the background and image
33 portions of the electrostatic latent image on photoconductive
34 surface 12.

35 Liquid toner spray apparatus 22 supplies liquid toner,
36 containing charged toner particles and carrier liquid, to the
37 area of propinquity between photoconductive surface 12
38 bearing the latent image and the surface of roller 20. As a

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1 result of the relative differences in voltages between the
2 surfaces of roller 20 and the image and background areas of
3 the latent image, toner particles selectively adhere to the
4 image portions of photoconductive surface 12, and the latent
5 image is thereby developed.

6 In a preferred embodiment of the invention, liquid toner
7 spray apparatus 22 is operative to sequentially provide a
8 multiplicity of pigmented toners, one for each of the process
9 colors, with or without black or other colors, as described
10 in PCT Publication WO 90/14619, the disclosure of which is
11 incorporated herein by reference. Other development
12 apparatus, as known in the art, can also be utilized in
13 imaging apparatus incorporating the duplex printing
14 arrangement of the present invention.

15 After the latent image has been developed,
16 photoconductive surface 12 is engaged by an excess liquid
17 removal assembly 24, such as a squeegee roller, which serves
18 to compact the toner image, reduce the amount of carrier
19 liquid therein and remove carrier liquid from the
20 background areas on photoconductive surface 12. Squeegee
21 roller 24 is preferably formed of resilient, slightly-
22 conductive, polymeric material and is charged to a relatively
23 high voltage with the same polarity as that of the toner
24 particle charge.

25 Downstream of squeegee roller 24, photoconductive surface
26 12 bearing the developed image is engaged by intermediate
27 transfer member 40, which may be a drum or belt. Intermediate
28 transfer member 40 preferably has a surface comprising a
29 resilient slightly conductive polymeric material, and which
30 may be heated by means of a heater 41. Alternatively or
31 additionally, intermediate transfer member 40 may be charged
32 to an electric potential having a polarity opposite that of
33 the developed image.

34 Intermediate transfer member 40 rotates in a direction
35 opposite that of drum 10, as shown by arrow 43, such that
36 there is substantially zero relative motion between their
37 respective surfaces where they contact. As both drum 10
38 bearing the developed latent image and intermediate transfer

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1 member 40 rotate, the developed toner image on
2 photoconductive surface 12 is transferred to the surface of
3 intermediate transfer member 40, by electrophoretic transfer
4 as is well known in the art.

5 Various types of intermediate transfer members are known
6 and are described, for example in U.S. Patent 4,684,238, PCT
7 Publication WO 90/04216 and U.S. Patent 4,974,027, the dis-
8 closures of all of which are incorporated herein by refer-
9 ence.

10 After the toner image has been transferred from
11 photoconductive surface 12 to intermediate transfer member
12 40, the photoconductive surface is engaged by a cleaning
13 station 49 which may be any conventional cleaning station as
14 is known in the art. A lamp 50 then removes any residual
15 charge which may remain on the photoconductive surface. Drum
16 10 then returns to its starting position, ready for
17 recharging and an additional imaging cycle.

18 After the developed latent image has been transferred
19 from photoconductive surface 12 to intermediate transfer
20 member 40 as described above, it is transferred again in a
21 second transfer procedure from intermediate transfer member
22 40 to a final substrate 44, such as a sheet of paper. Second
23 transfer, generally aided by heat and pressure, occurs as a
24 result of the engagement of the surface of intermediate
25 transfer member 42 with the substrate at a nip 45 formed with
26 the surface of an impression roller 42. Roller 42 rotates in
27 a direction opposite that of intermediate transfer member 40,
28 as indicated by an arrow 47. In a manner more fully
29 described below, the substrate is fed through nip 45 and the
30 developed image is transferred to the side of the substrate
31 facing intermediate transfer member 40. At the point of
32 transfer, the image is at least partially fused and fixed
33 upon the final substrate as a result of the application of
34 heat and pressure at the nip.

35 Although a wide variety of toners can be used in the
36 present invention, the preferred toners are those that are
37 suitable for at least partial fixing at the point of
38 transfer, for example, the liquid toner of Example 1 of

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1 United States Patent 4,842,974. When the preferred liquid
2 toners are used, the temperature and pressure at transfer to
3 the substrate is adjusted so that no additional fusing
4 apparatus is necessary for normal handling of the image.

5 In an alternative embodiment a powder toner development
6 system is used. In such a system the characteristics of the
7 toner and the velocities, temperatures and pressures of the
8 elements involved are such that, preferably, at least partial
9 fixing of the image to the paper takes place during second
10 transfer.

11 Simultaneous transfer and fusing of liquid toner images
12 is known and described, for example, in United States Patent
13 4,708,460, and in PCT Published Application WO 90/4216, the
14 disclosures of which are incorporated herein by reference.

15 Substrate 44 is initially fed through nip 45 from a
16 spring-mounted tray 68 (located to the right of impression
17 roller 42) which is adapted to hold individual sheets of
18 paper or any other substrate suitable for receiving the
19 developed image. The uppermost sheet in tray 68 is engaged by
20 a roller 70 which, in response to an appropriate control
21 signal, rotates in a clockwise direction and causes the
22 uppermost sheet to move laterally in the direction of nip
23 45. The sheet is guided towards the nip by means of a fixed
24 plate 72 and one or more pairs of wheels which are attached
25 to plate 72 and to the end of an arm 74 which is pivotally
26 attached to roller 70. A gripper 76, mounted on impression
27 roller 42, is operative to grip the leading edge of the
28 substrate as it is fed to roller 42. The substrate is then
29 conveyed through the nip in the direction of the rotation of
30 roller 42.

31 After the substrate has been transported through nip 45
32 and the developed image transferred to the substrate,
33 gripper 76 releases the substrate from engagement with roller
34 42. In accordance with a preferred embodiment of the
35 invention, the substrate is then directly conveyed, in a
36 manner more fully described below, either to an output tray
37 80 or to a waiting station 82. For multi-color imaging
38 requiring separate image transfer for each of the process

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1 colors, gripper 76 maintains its grip on the substrate as the
2 substrate is repeatedly conveyed around impression roller 42
3 and through nip 45 until all the color images have been
4 transferred to the substrate. Only then does gripper 76
5 release substrate 44 for transport either to output tray 80
6 or waiting station 82.

7 Reference is now made also to Fig. 2 which shows a
8 perspective view of substrate deflection apparatus 81, in
9 accordance with a preferred embodiment of the present
10 invention. Deflection apparatus 81 includes a shaft 87 which
11 is spaced from impression roller 42 by means of spacers 88
12 which freely rotate about shaft 87. Fixedly attached to shaft
13 87 are pairs of arms 89 whose opposite end portions are
14 pivotally attached to pairs of arms 93 at pivots 92.
15 Rotatably attached to the opposite end portions of arms 93
16 are wheels 90 which engage a motorized roller 86. A spring
17 94, at pivot 92, is operative to spring load wheels 90 on the
18 surface of roller 86.

19 After complete transfer of the toner images to the side
20 of the substrate being printed, gripper 76 opens and
21 releases the substrate at a point just above a stripper 91,
22 as shown in Fig. 2. The substrate is thus directed away from
23 the surface of impression roller 42 and along the face of
24 stripper 91, in the direction of the nip defined by roller
25 86 and wheels 90. With roller 86 rotating as shown, the
26 substrate is drawn through the nip and is deflected by the
27 action of the nip either to waiting station 82 (as shown in
28 Fig. 3) or to output tray 80 (as shown in Fig. 4). A groove
29 97 on shaft 87 allows for axial positioning of arms 89 along
30 shaft 87 so as to better accommodate various sizes of
31 substrates.

32 When it is desired to print an image on the second side
33 of the substrate, the substrate is deflected to waiting
34 station 82, as shown in Fig. 3. In such event, prior to the
35 release of the substrate from gripper 76, shaft 87 is rotated
36 slightly in a counter-clockwise direction, which results in
37 the extension of arms 89 and 93 at pivot 92 such that the
38 effective angle between arms 89 and 93 is close to 180°.

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1 This extension of arm 93 results in a displacement of wheels
2 90 along the surface of roller 86 in a direction away from
3 impression roller 42. When the substrate is drawn through the
4 nip defined by roller 86 and wheels 90, the angle of release
5 is such that substrate 44 is conveyed to waiting station 82,
6 as shown in Fig 3. The final delivered position of substrate
7 44 is indicated by reference number 44A. Note that the
8 trailing edge of the substrate lies on wheels 102, whose
9 function is described below in conjunction with Figs. 5 and
10 6.

11 When image transfer to the substrate has been completed
12 (e.g., when printing on both sides of the substrate is
13 complete, or single side printing is desired), the substrate
14 is deflected to output tray 80, as shown in Fig. 4. In such
15 event, prior to the release of the substrate from gripper 76,
16 shaft 87 is rotated slightly in a clock-wise direction, which
17 results in a closing of arms 89 and 93 at pivot 92 such that
18 the effective angle between them is close to 90°. This
19 closing results in an upwards displacement of wheels 90 on
20 the surface of roller 86. When the substrate is drawn through
21 the nip defined by roller 86 and wheels 90, the angle of
22 release is such that substrate 44 is conveyed to output tray
23 80, as shown in Fig. 4.

24 A pair of partial rings 95 are situated along roller 86
25 (but do not rotate with roller 86) as shown in Fig. 2 to
26 provide for a slight bending of the sides of substrate 44 as
27 it engages roller 86, thereby increasing its apparent
28 stiffness and assuring that it is properly deflected to
29 output tray 80. Partial rings 95 are positioned so that they
30 do not engage substrate 44 when the substrate is to be
31 delivered to the waiting station, since the additional
32 stiffening would inhibit the required bending of the
33 substrate as it leaves the nip. Rings 95 are slideable along
34 the surface of roller 86 to accommodate different substrate
35 sizes.

36 Reference is now made also to Fig. 5 which shows a
37 perspective view of substrate transport apparatus for duplex
38 printing, referenced generally by numeral 78, in accordance

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1 with a preferred embodiment of the invention. Transport
2 apparatus 78 preferably includes a set of rubberized wheels
3 102 which are mounted on a motorized shaft 79 and which
4 protrude through apertures 101 in a plate 100, laterally
5 spaced between impression roller 42 and waiting station 82.
6 Pivotally attached to plate 78 is a curved arm 104, and
7 attached to the opposite end portion of arm 104 is a rod 106.
8 Rod 106 has a set of freely-rotating knurled wheels 103
9 thereon which are in alignment with wheels 102.

10 When the substrate is delivered to waiting station 82,
11 arm 104 is in an "upper" open position, as shown in Figs. 3
12 and 5, and what was the trailing edge of the substrate falls
13 upon wheels 102. Upon an appropriate signal, arm 104 pivots
14 to a "closed", lower position, as shown in Fig. 6, and the
15 edge of the substrate is then held within a nip defined by
16 wheels 102 and wheels 103. Motorized shaft 79 and wheels 102
17 then rotate in a clock-wise direction as shown and transport
18 the substrate through the nip to impression roller 42.
19 Alternatively wheels 102 rotate continuously but only move
20 the paper when arm 104 is closed.

21 The delivery of the substrate to impression roller 42 is
22 timed such that gripper 76 is appropriately located to
23 receive the edge of the substrate as it reaches roller 42.
24 Preferably, the rotation rate of wheels 102 is such that the
25 paper moves faster than the surface of roller 42. This has a
26 twofold advantage. Firstly, the timing of the closing of arm
27 104 is less critical, since the arm can be closed late
28 allowing the substrate to buckle as shown in Fig. 6.
29 Secondly, the resulting buckle improves the alignment by
30 allowing the edge of the paper to butt against the grippers.
31 To aid the proper placement of the paper in the gripper arms
32 a guide 60 closely spaced from roller 42 is provided.

33 The substrate is then fed around impression roller 42 and
34 through nip 45. It will be appreciated that in this pass
35 through nip 45, it is the second side of the substrate which
36 faces intermediate transfer member 42, and duplex image
37 transfer is thereby attained. Since the leading edge of the
38 substrate during duplex transfer had been the trailing edge

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1 during image transfer to the first side, the image
2 transferred to the duplex side must be inverted in order to
3 maintain the same orientation on both sides of the substrate.

4 It is a specific feature of some embodiments of the
5 present invention that no more than one substrate is located
6 within waiting station 82 at any one time. As shown in Fig.
7 6, the apparatus is configured such that a substrate 44'
8 which has been in waiting station 82 is transported back to
9 roller 42 for duplex printing at the same time that another
10 substrate 44" is being delivered to waiting station 82. In
11 this manner, the apparatus is in almost constant operation
12 without any wasted rotations. Thus, the present invention
13 allows for continuous duplex printing without complicated re-
14 feed mechanisms or multi-sheet buffer storage. As a result,
15 in the event of jams or other problems causing an
16 interruption in operation, no more than two sheets need be
17 discarded or reprinted when the system is restarted.

18 It will also be appreciated that the invention affords
19 the possibility of both single sided and duplex printing, and
20 in the context of duplex printing, several different printing
21 sequences are possible.

22 In a first preferred embodiment of the invention which
23 maximizes the efficiency of the apparatus, the first side of
24 a first substrate is printed and the substrate is delivered
25 to waiting station 82. Then the first side of a second
26 substrate is printed. While this substrate is being delivered
27 to waiting station 82, the first substrate is removed
28 therefrom and delivered to the impression roller for printing
29 on its second side. While the first substrate is being
30 delivered to the output tray, the second substrate is removed
31 from the waiting station and delivered to the impression
32 roller for printing on its second side. The second substrate
33 is then delivered to the output tray. This process is
34 repeated until all the required prints are completed.

35 In a second preferred embodiment of the invention which
36 maximizes the efficiency of the apparatus, the first side of
37 a first substrate is printed and the substrate is delivered
38 to waiting station 82. Then the first side of a second

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1 substrate is printed. While this substrate is being delivered
2 to waiting station 82, the first substrate is removed
3 therefrom and delivered to the impression roller for printing
4 on its second side. While the first substrate is being
5 delivered to the output tray, the third substrate is
6 delivered to the apparatus for printing on its first side,
7 followed by printing of the second side of the second
8 substrate. This process of alternately printing the second
9 side of a substrate in the waiting station and the first side
10 of a new substrate continues until all the required prints
11 are completed.

12 It should be understood that the prints on any two
13 succeeding substrates need not be the same. In fact, the
14 duplexer of the present invention is especially suitable for
15 electronic collation in which a number of successive pages
16 are printed with different images to form a set which is then
17 bound by an optional finisher and delivered from the printer.
18 The images to be printed are preferably stored in a fast
19 memory and are successively delivered to the laser imager for
20 forming the successive images on the surface of drum 10.

21 It will be appreciated by persons skilled in the art that
22 the present invention is not limited to what has been partic-
23 ularly shown and described hereinabove. Rather, the scope of
24 the present invention is defined only by the claims that
25 follow:

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CLAIMS

2 1. Imaging apparatus for duplex printing on a substrate
3 having first and second sides and a leading edge and a
4 trailing edge, the apparatus comprising:

5 a first member having an image support surface adapted to
6 sequentially support first and second images thereon;

7 a second member adapted to support the substrate such
8 that one side of the substrate engages the image support
9 surface, leading edge first, at a transfer region;

10 means for transferring the first image from the image
11 support surface to the first side of the substrate at the
12 transfer region while at least partially fixing the image
13 thereto;

14 a waiting station adjacent the second member for
15 receiving the substrate after transfer of the first image
16 thereto and prior to the transfer of the second image
17 thereto;

18 an output station for receiving the substrate after
19 completion of image transfer thereto;

20 deflector means adjacent the second member operative to
21 receive the substrate directly from the second member and
22 selectably deflect the substrate towards the waiting station
23 or the output station for delivery thereto; and

24 roller means associated with the waiting station for
25 selectably engaging the trailing edge of the substrate after
26 the substrate has been delivered to the waiting station and
27 for delivering the substrate back to the second member, the
28 second member being operative to deliver the substrate to the
29 transfer region, whereat the second image is transferred to
30 the second side of the substrate.

31

32 2. Apparatus according to claim 1 wherein the second member
33 further comprises gripping means for gripping the edge of the
34 substrate which enters the transfer region first.

35

36 3. Apparatus according to claim 1 wherein the second member
37 is adapted for repeatedly engaging the same side of the
38 substrate with the image support surface, such that at each

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1 engagement a different color image is transferred thereto.

2

3 4. Apparatus according to claim 1 wherein the deflector
4 means comprises a roller and a set of wheels engaging the
5 roller and forming a nip through which the substrate is
6 transported, the set of wheels adapted to engage the roller
7 at first and second positions, at the first position the
8 angle of release of the substrate from the nip is such that
9 it is deflected to the waiting station, and at the second
10 position the angle of release of the substrate from the nip
11 is such that the it is deflected to the output tray.

12

13 5. Apparatus according to claim 1 wherein the deflector
14 means comprises:

15 a shaft;

16 a motorized roller;

17 at least one pair of arms joined to each other at a pivot
18 and spring-loaded with respect to each other at the pivot,
19 one of the arms fixedly attached to the shaft and the other
20 arm having a wheel rotatably attached thereto and forming a
21 nip with respect to the roller; and

22 means for rotating the shaft to first and second
23 positions, whereby at the first position the deflector means
24 is operative to deflect the substrate to the waiting station
25 and at the second position the deflector means is operative
26 to deflect the substrate to the output station.

27

28 6. Apparatus according to claim 5 wherein the at least one
29 pair of arms comprises at least two pairs of arms axially
30 distanced from each other with respect to the shaft.

31

32 7. Apparatus according to claim 6 wherein the at least one
33 pair of arms is axially slideable along the shaft.

34

35 8. Apparatus according to claim 5 wherein the roller further
36 includes stiffener members axially slideable thereon.

37

38 9. Apparatus according to claim 1 wherein the deflector

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1 means is operative to deflect a substrate to the waiting
2 station while the roller means is operative to deliver a
3 different substrate from the waiting station back to the
4 second member.

5

6 10. Apparatus according to claim 1 wherein the roller means
7 comprises a motorized set of wheels and a roller selectably
8 adapted to engage the trailing edge of the substrate at a nip
9 formed with the wheels.

10

11 11. Apparatus according to claim 10 wherein the roller is
12 adapted to be in an open, disengaged position with respect to
13 the wheels prior to the deflection of a substrate to the
14 waiting station, whereby the trailing edge of the substrate
15 contacts the wheels when it is deflected to the waiting
16 station, and in a closed, engaged position with respect to
17 the wheels when the substrate is delivered back to the second
18 member.

19

20 12. Apparatus according to claim 1 wherein the roller means
21 comprises:

22 a base plate having at least one aperture therethrough;
23 a motorized rotatable shaft having at least one
24 rubberized wheel mounted thereon and extending through the
25 aperture; and

26 at least one roller pivotally mounted with respect to the
27 plate, and selectably operative to form a nip with respect to
28 the at least one wheel for delivery of a substrate
29 therethrough, whereby the at least one roller is in a first
30 disengaged position with respect to the at least one wheel
31 prior to the deflection of a substrate to the waiting station
32 and in a closed, engaged position with respect to the at
33 least one wheel when the substrate is delivered back to the
34 second member.

35

36 13. Apparatus according to claim 1 and including means for
37 causing the engagement of the first sides of sequential
38 substrates with the image bearing surface for image transfer

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- 1 thereto prior to causing the engagement of the second sides
2 of sequential substrates for image transfer thereto.
3
- 4 14. Paper delivery apparatus for a duplex printer comprising:
5 a shaft;
6 a motorized roller spaced from the shaft;
7 at least one pair of arms joined at a pivot and spring
8 loaded with respect to each other at the pivot, one end
9 portion of the pair of arms fixedly attached to the shaft and
10 the opposite end portion having a wheel rotatably attached
11 thereto and defining a nip with respect to the roller;
12 means for transporting a substrate through the nip;
13 a waiting station and an output station adapted to
14 receive the substrate upon exiting from the nip; and
15 means for selectably rotating the shaft to first and
16 second positions, such that at the first position the sub-
17 strate exits from the nip to the waiting station and at the
18 second position the substrate exits from the nip to the
19 output station.
20
- 21 15. Apparatus according to claim 14 wherein the at least one
22 pair of arms comprises at least two pairs of arms axially
23 distanced from each other with respect to the shaft.
24
- 25 16. Apparatus according to claim 14 wherein the at least one
26 pair of arms is axially slideable along the shaft.
27
- 28 17. Apparatus according to claim 14 wherein the roller
29 further includes stiffener members axially slideable thereon.
30
- 31 18. Apparatus according to claim 14 wherein rotation of the
32 shaft to the first position causes movement of the wheel
33 along the roller so that the angle of release of the
34 substrate from the nip is such that it is deflected to the
35 waiting station, and rotation of the shaft to the second
36 position causes reverse movement of the wheel along the
37 roller so that the angle of release of the substrate from
38 the nip is such that it is deflected to the output station.

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- 1
2 19. Apparatus for printing toner images on both sides of a
3 plurality of sequential substrates comprising:
4 printing means for printing toner images on one side of a
5 substrate;
6 a waiting station spaced closely to the printing means
7 and adapted for holding only one substrate at any one time
8 after printing of images on the first side thereof; and
9 delivery means associated with the waiting station for
10 delivering a substrate from the waiting station back to the
11 printing means for printing on the second side thereof, a
12 first substrate being removed from the waiting station while
13 another substrate is being delivered to the waiting station
14 after printing on the first side thereof.
15
- 16 20. Apparatus according to claim 1 wherein the first and
17 second images are toner images.
18
- 19 21. Apparatus according to claim 1 wherein the first and
20 second images are liquid toner images.
21
- 22 22. Apparatus according to claim 19 wherein the toner images
23 are liquid toner images.
24
- 25 23. Apparatus according to claim 1 and including means for
26 printing different images on the first and second
27 substrates.
28
- 29 24. Apparatus according to claim 19 and including means for
30 printing different images on the first and second substrates.
31
- 32 25. A method for printing images on first and second sides of
33 sequential substrates comprising the steps of:
34 (a) printing an image on the first side of a first
35 substrate;
36 (b) delivering the first substrate to a waiting station;
37 (c) printing an image on the first side of a subsequent
38 substrate;

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1 (d) delivering the subsequent substrate to the waiting
2 station while removing the first substrate therefrom;

3 (e) printing an image on the second side of the first
4 substrate;

5 (f) delivering the first substrate to an output station
6 while removing the second substrate from the waiting station;

7 (g) printing an image on the second side of the
8 subsequent substrate.

9 (g) repeating steps (a) - (f) above for a plurality of
10 sequential substrates.

11

12 26. A method for printing images on first and second sides of
13 sequential substrates comprising the steps of:

14 (a) printing an image on the first side of a first
15 substrate;

16 (b) delivering the first substrate to a waiting station;

17 (c) printing an image on the first side of a subsequent
18 substrate;

19 (d) delivering the subsequent substrate to the waiting
20 station while removing the first substrate therefrom;

21 (e) printing an image on the second side of the first
22 substrate;

23 (f) delivering the first substrate to an output station;

24 (g) printing an image on the first side of a third
25 substrate;

26 (h) delivering the third substrate to the waiting station
27 while removing the second substrate from the waiting station;

28 (i) printing an image on the second side of the second
29 substrate.

30 (j) repeating steps (g) - (i) a plurality of times.

31

32 27. A method for printing images on first and second sides of
33 sequential substrates utilizing apparatus having an image
34 bearing roller and an impression roller forming a nip
35 therebetween, comprising the steps of:

36 (a) passing a first substrate through the nip during a
37 first revolution of the image bearing roller to print an
38 image on the first side of a first substrate;

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- 1 (b) delivering the first substrate to a waiting station;
2 (c) passing a second substrate through the nip during a
3 subsequent revolution of the image bearing roller to print an
4 image on the first side of the second substrate; and
5 (e) passing the first substrate through the nip during
6 the next revolution of the image bearing roller after the
7 subsequent revolution to print an image on the second side
8 of the first substrate.

9
10 28. A method for printing images on first and second sides of
11 sequential substrates utilizing apparatus having an image
12 bearing roller and an impression roller forming a nip
13 therebetween, comprising the steps of:

- 14 (a) passing a first substrate through the nip during a
15 first series of revolutions of the image bearing roller to
16 print a plurality of color separation images on the first
17 side of a first substrate;
18 (b) delivering the first substrate to a waiting station;
19 (c) passing a second substrate through the nip during a
20 subsequent revolution of the image bearing roller to print an
21 image on the first side of the second substrate; and
22 (e) passing the first substrate through the nip during
23 the next revolution of the image bearing roller after the
24 subsequent revolution to print an image on the second side
25 of the first substrate.

26
27 29. A method according to claim 28 and including the step of
28 passing the second substrate through the nip at least one
29 time between step (a) and step (c) thereby to print at least
30 one additional image on the first side of the second
31 substrate.

32
33 30. A method according to claim 25 wherein the first and
34 second images are toner images.

35
36 31. A method according to claim 26 wherein the first and
37 second images are toner images.

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1 32. A method according to claim 27 wherein the first and
2 second images are toner images.

3

4 33. A method according to claim 28 wherein the first and
5 second images are toner images.

6

7 34. A method according to claim 25 wherein different images
8 are printed on the first and second substrates.

9

10 35. A method according to claim 26 wherein different images
11 are printed on the first and second substrates.

12

13 36. A method according to claim 27 wherein different images
14 are printed on the first and second substrates.

15

16 37. A method according to claim 28 wherein different images
17 are printed on the first and second substrates.

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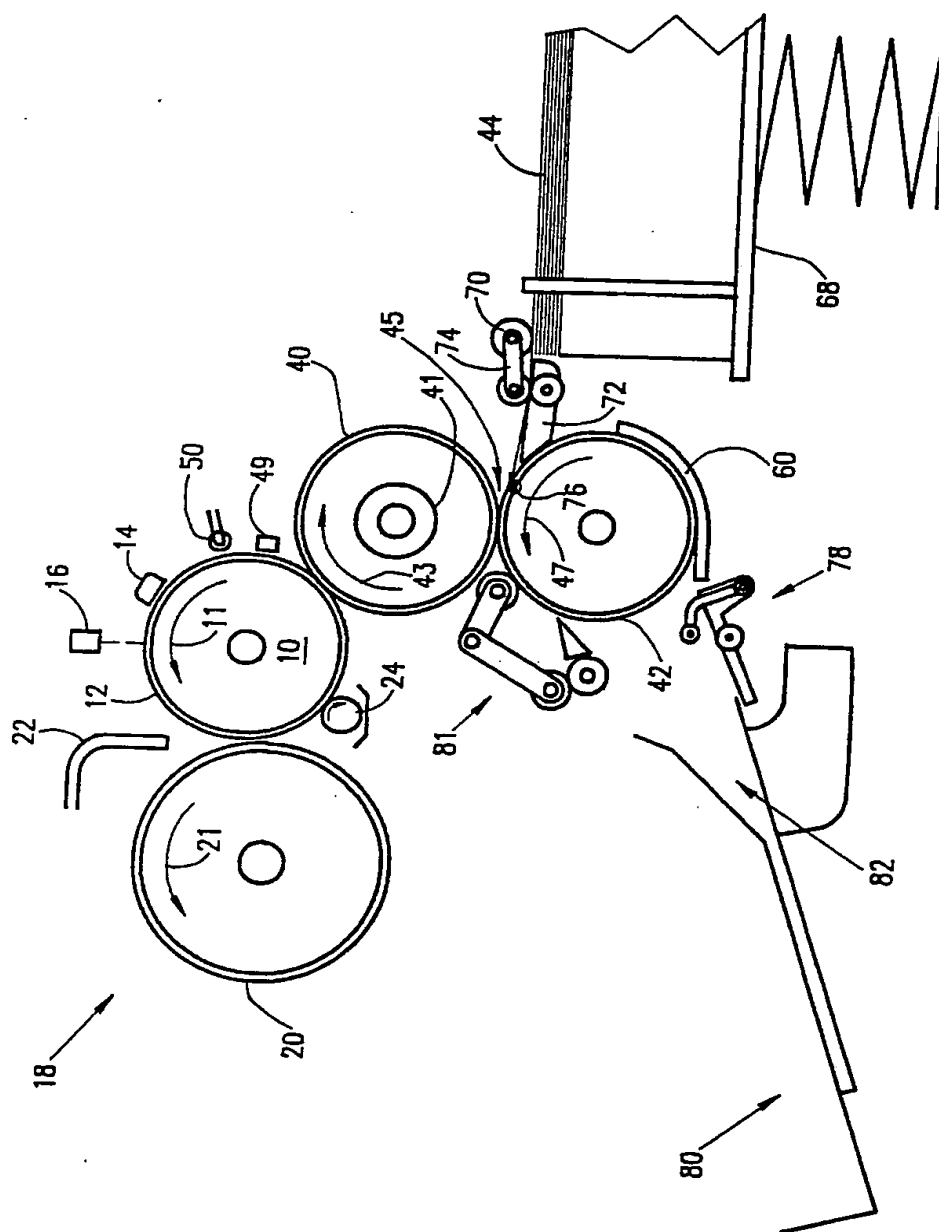
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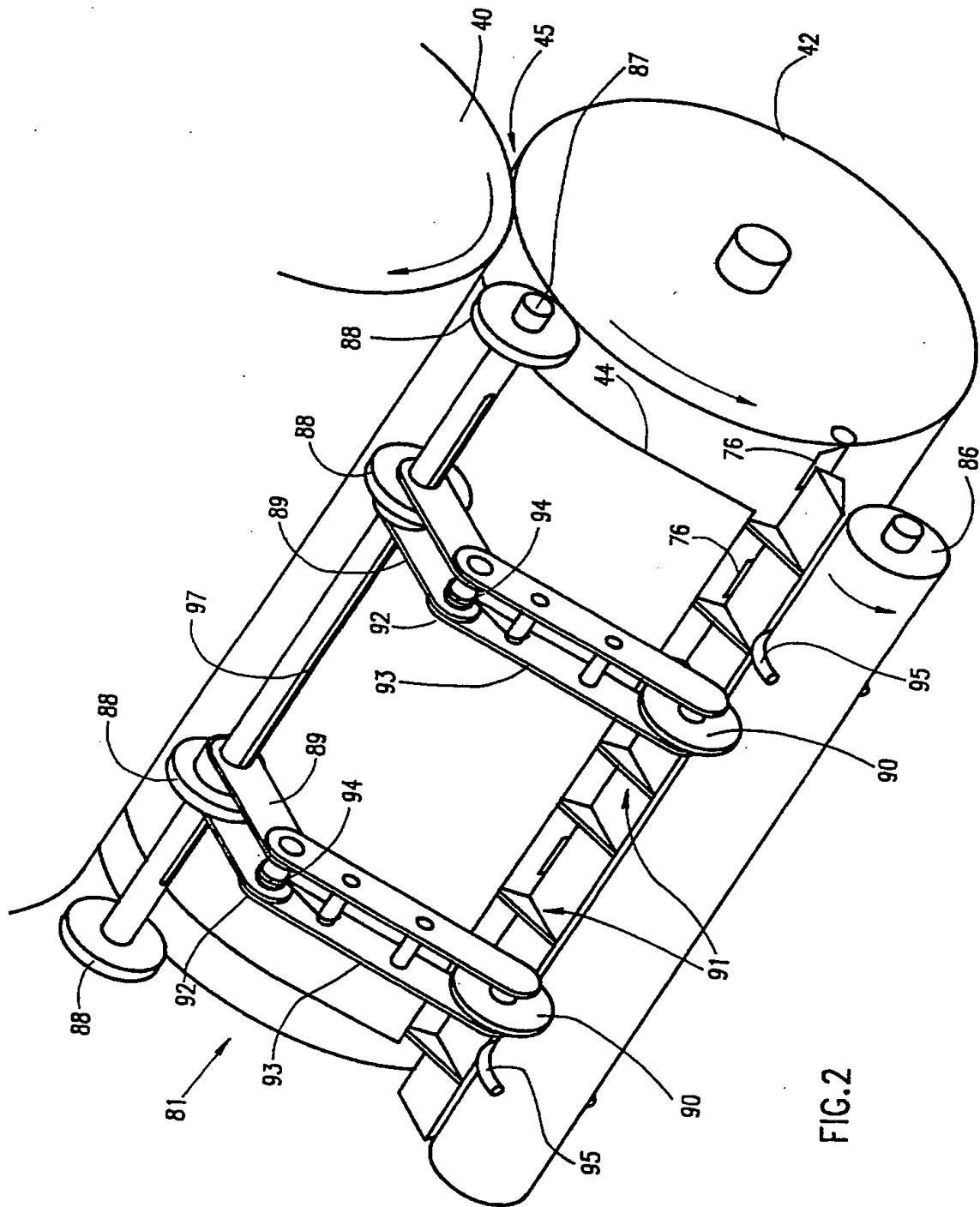
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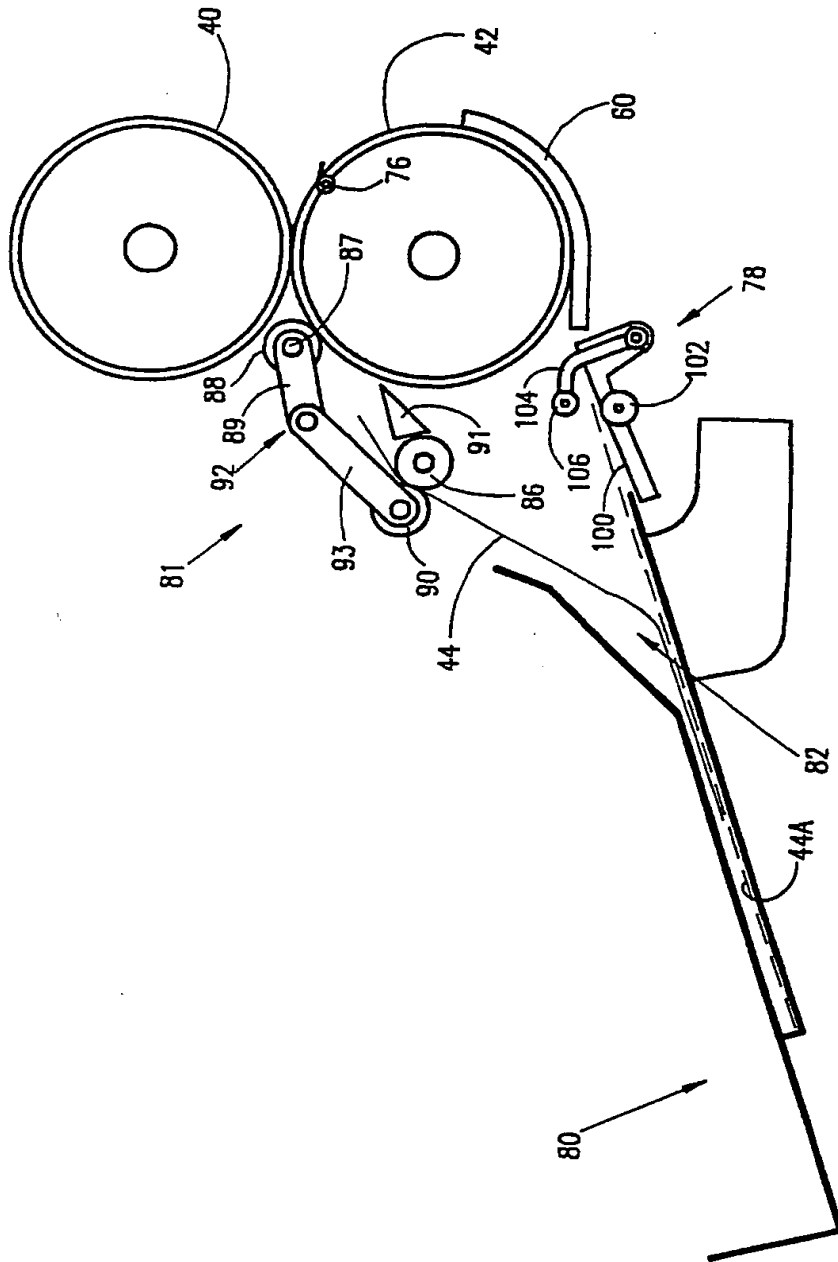


FIG. 3

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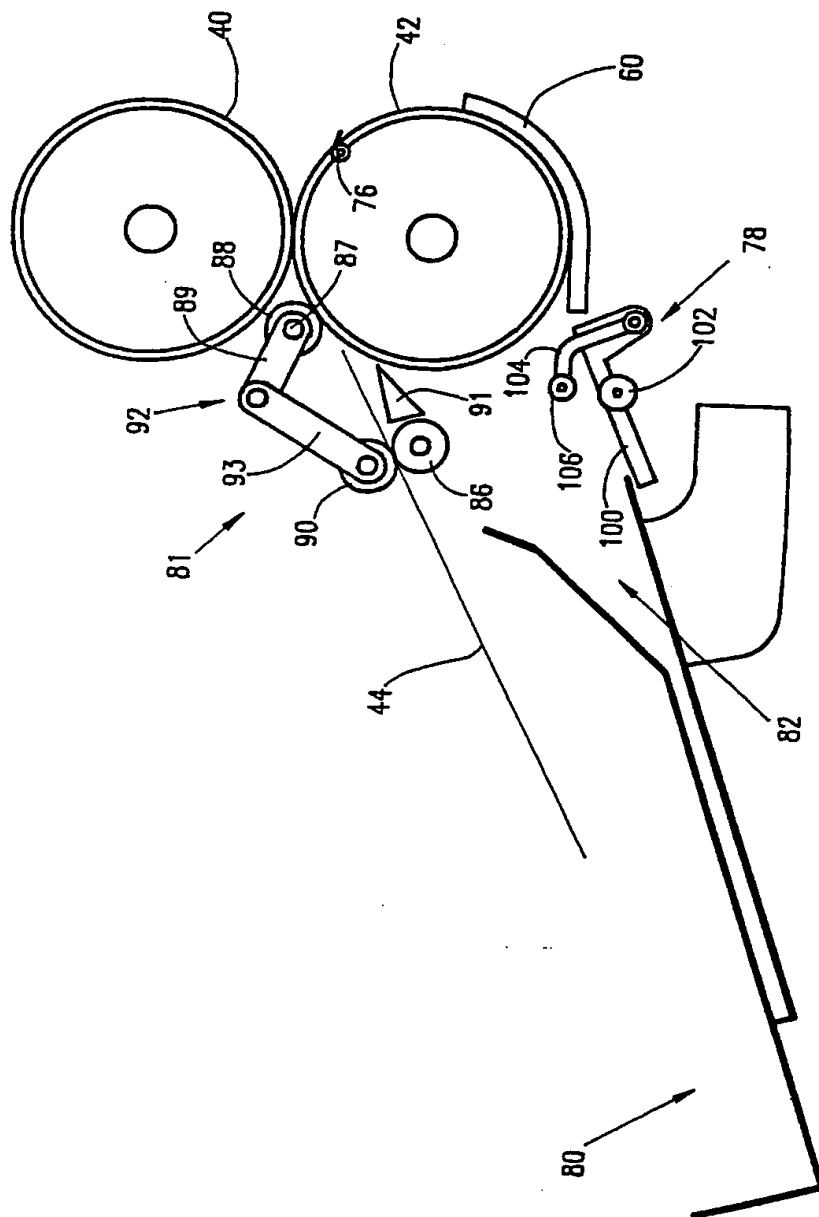


FIG. 4

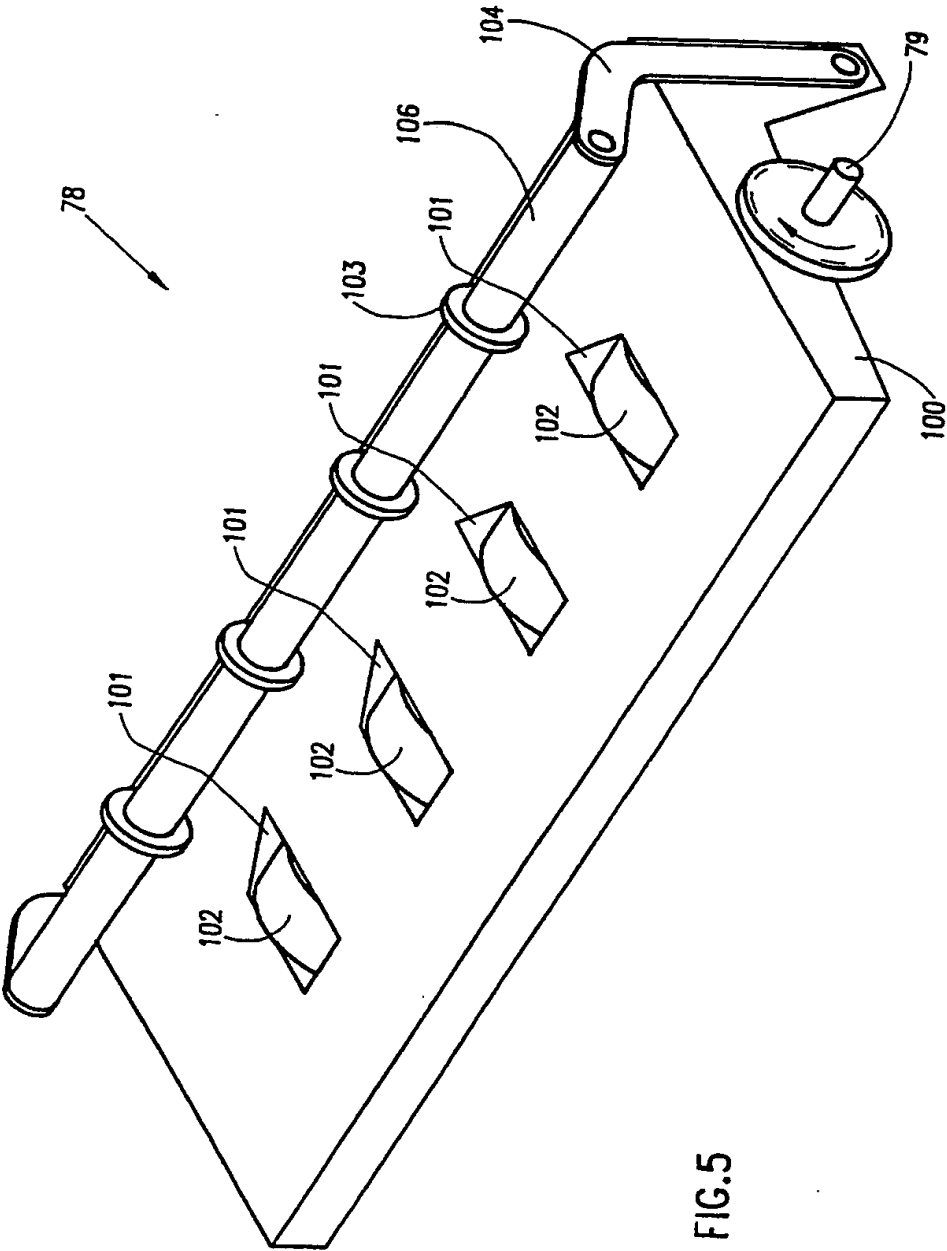


FIG. 5

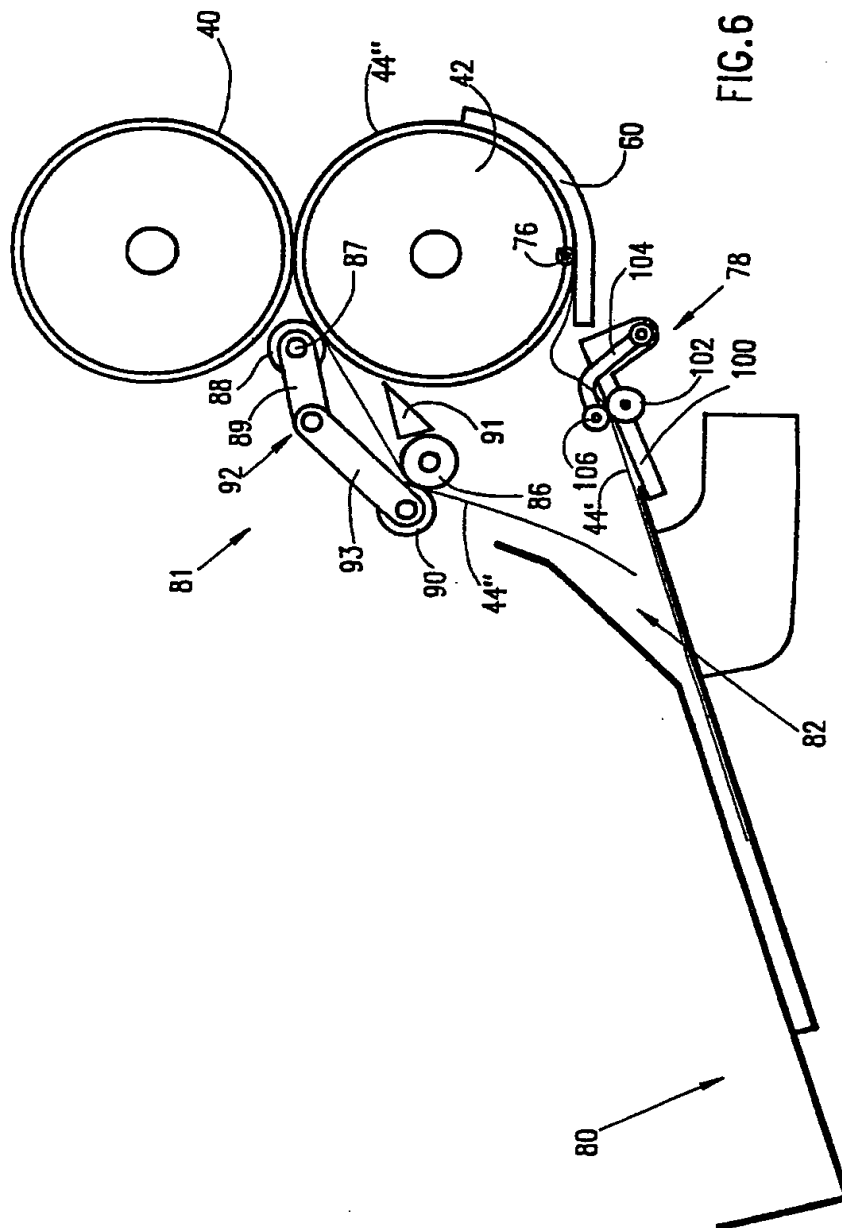



FIG. 6

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INTERNATIONAL SEARCH REPORT

International Application No PCT/NL 91/00151

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC5: G 03 G 15/00, 15/22		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC5	B 65 H; G 03 G	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	US, A, 4806979 (HIROYOSHI TOKORO ET AL) 21 February 1989, see column 3, line 59 - column 4, line 2; figures 1,7,8	25,26, 30,31
Y	US, A, 4814822 (THOMAS ACQUAVIVA ET AL) 21 March 1989, see figure 1 detail 25	1,20, 21
Y	EP, A2, 0147341 (RHONE-POULENC SYSTEMES) 3 July 1985, see page 11, line 1 - line 5 detail 8	1,20, 21
A		27,28
<p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"A" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
9th April 1992	18.05.92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 Nathalie Walther	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	GB, A, 2099759 (XEROX CORPORATION) 15 December 1982, see abstract; figure 1 --	19
Y	US, A, 4568169 (KENICHI WADA ET AL) 4 February 1986, see column 5, line 53 - line 68; figure 2; claim 3 detail 28 --	19
A	US, A, 4639126 (KENNETH A. BUSHAW ET AL) 27 January 1987, see figure 1; claim 1 --	1-37
A	EP, A1, 0372294 (MITA INDUSTRIAL CO., LTD.) 13 June 1990, see figures 1,3 detail A --	1-13,19, 22,24
A	EP, A2, 0342704 (CANON KABUSHIKI KAISHA) 23 November 1989, see column 3, line 14 - line 52; figure 1 --	28,29, 33,37
A	US, A, 4428667 (RUSSEL L. PHELPS ET AL) 31 January 1984, see figures 2-4 -- -----	14-18

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/NL 91/00151**

SA 50248

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 28/02/92. The European Patent office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4806979	21/02/89	DE-A- 3718219 JP-A- 62280133	03/12/87 05/12/87
US-A- 4814822	21/03/89	NONE	
EP-A2- 0147341	03/07/85	FR-A-B- 2557317 JP-A- 60221773 US-A- 4607940	28/06/85 06/11/85 26/08/86
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US-A- 4568169	04/02/86	DE-A- 3228570 JP-A- 58021266 JP-A- 58021267 JP-A- 58021268 JP-A- 58021269	17/02/83 08/02/83 08/02/83 08/02/83 08/02/83
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US-A- 4428667	31/01/84	CA-A- 1205500 EP-A-B- 0100675 JP-A- 59043755	03/06/86 15/02/84 10/03/84

For more details about this annex: see Official Journal of the European patent Office, No. 12/82